



# **Thermal Spray and Machine, Inc.**

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## **Marine Applications of Thermal Spray Technology**

### **Hard Chrome Alternatives Team Meeting**

**San Diego, CA 25 January 2006**

**Jim Galvin, President, Thermal Spray & Machine, Inc.**

**Dave Donohue, Corporate Technical Director, TSM, Inc.**

**Charlie Hurd, West Coast Representative, TSM, Inc.**

**Chris Nichols, Vice President, Sales & Marketing, TSM, Inc.**

Report Documentation Page				Form Approved OMB No. 0704-0188	
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a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			



Thermal Spray & Machine Inc.

## CUSTOMER BASE

- **Approx. 40-45% of Overall Sales Volume – U.S. Military**  
**Navy – Army – Coast Guard – Military Sealift Command**

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- **Support Center For Shipyards, Manufacturing Plants, Electrical, Hydraulic, and Mechanical Repair Facilities and Original Equipment Manufacturers**

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- **Commercial Customers**  
**Anheuser-Busch – Dupont – Weyerhaeuser – Alcoa**  
**Georgia Pacific - International Paper - Phillip Morris**  
**Honeywell Performance Fibers ... and a host of others..! !**

# *Thermal Spray & Machine, Inc. - CERTIFICATIONS*

1. **SUPERVISOR OF SHIPBUILDING, CONVERSION & REPAIR, US NAVY, PORTSMOUTH, VA** Certification of Facilities in accordance with NAVSEA MIL-STD 1687A
2. **COMMANDER NAVAL SEA SYSTEMS COMMAND (SEA 05M2)** Approval of TSM's Thermal Spray Coating Procedure FP-WC-01 for HVOF Application of Tungsten Carbide
3. **COMMANDER NAVAL SEA SYSTEMS COMMAND (SEA 05M2)** Approval of TSM's Thermal Spray Coating Procedure for HVOF Application of Alloy 625
4. **NAVAL SURFACE WARFARE CENTER, CRANE DIVISION** Certification of Facility IAW NAVSEA S9320-AM-PRO-030/MLDG Rev 02, Vol. III
5. **COMMANDING OFFICER, SUBMEPP** NAVSEA Qualification to Manufacture MIL-C-24231 Connector Plugs for Submarine Cables
6. **AMERICAN BUREAU OF SHIPPING** Certificate of Type Approval No. NN498634 of TSM's Thermal Spray Coatings Including Main Propulsion Shafting Applications
7. **AMERICAN BUREAU OF SHIPPING** Certificate of Design Assessment No. 04-HS410093/2-PDA of TSM's Process F/P WC-01 for Repair and Restoration of Marine Machinery Components
8. **AMERICAN BUREAU OF SHIPPING** Certificate of Manufacturing Assessment No. NN498634 of TSM's Facilities and Associated Quality Procedures to Apply Coatings That Meet ABS Designated Standards
9. **LLOYD'S REGISTER** Certificate of Approval No. MNDE/REP/0001/01 of TSM's Arc Spraying and HVOF Spraying Procedures



# U.S. Department of Defense

Office of the Assistant Secretary of Defense (Public Affairs)

## News Release

No. 851-04

IMMEDIATE RELEASE

September 1, 2004

### DoD Issues Green Procurement Policy

The Department of Defense today announced an important step forward in its efforts to align mission and environmental stewardship by issuing a new “green procurement” policy. The policy affirms a goal of 100 percent compliance with federal laws and executive orders requiring purchase of environmentally friendly, or “green” products and services.

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## *Thermal Spray Process And Coatings Comply With DoD Green Procurement Policy...*

- **NO** Hexavalent Chrome !
- **NO** Cadmium !
- **NO** Lead !
- **NO** Phosphates !
- **NO** Halogens !
- **NO** Volatile Organic Compounds (VOC's) !

# **Applications of HVOF Thermal Spray**

- **Bearing & Seal Journals**
- **Manufacturing Rolls**
- **Compressor Parts**
- **Pump Shafts**
- **Blower Shafts**
- **Armature Shafts**
- **Hydraulic Rods**
- **Gear Fits**
- **Pump Casings**
- **Impellers**
- **Centrifuges**
- **Turbine Shafts**
- **Sleeves**
- **Axle Shafts**
- **Camshaft Journals**
- **Pistons/Piston Rods**
- **Crankshafts**
- **Bow Thruster Shafts**
- **Bearing Fits**
- **Propeller Shafts**
- **Rudder Posts**
- **Valve Stems**
- **Main Propulsion Shafts**
- **Plungers**
- **Mandrels**
- **Packing Glands**



# MARINE APPLICATIONS

*INNOVATION !      EXPERIENCE !      QUALITY !*



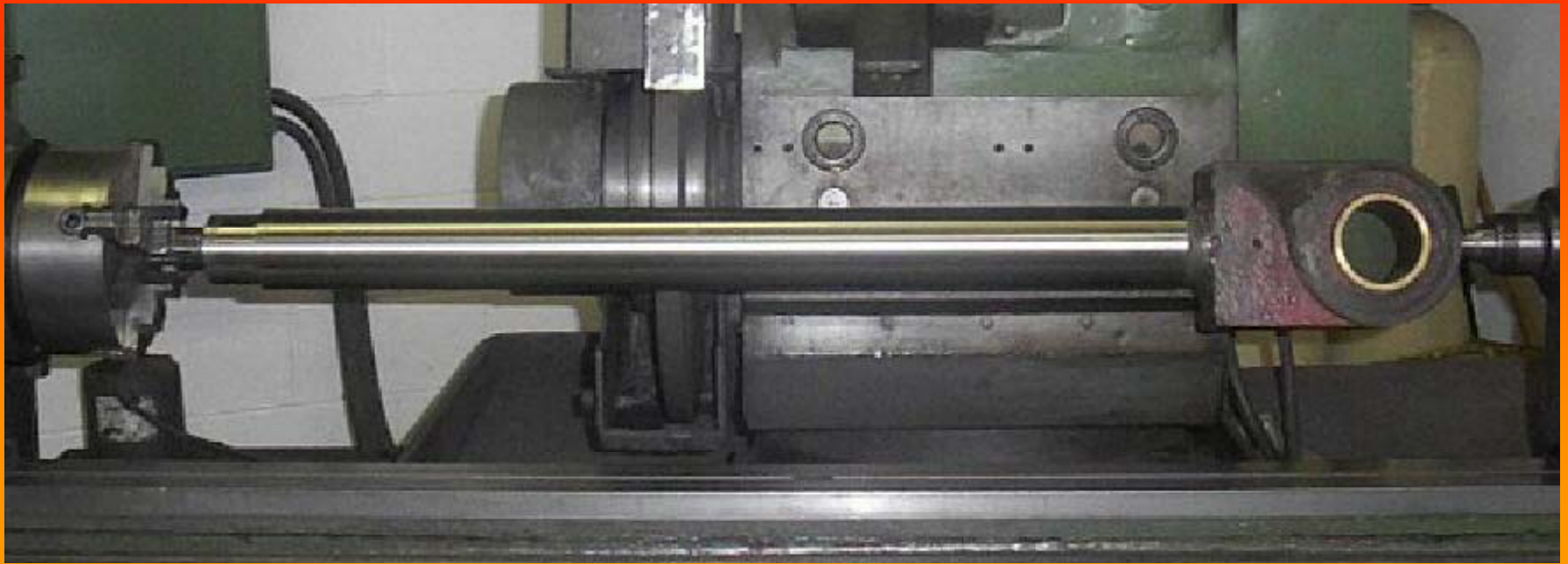
# **HARD CHROME REPLACEMENT**

***INNOVATION !      EXPERIENCE !      QUALITY !***



# **HYDRAULIC CYLINDER ROD**

**Shaft Coated With HVOF Applied Tungsten Carbide**



**HVOF Applied Tungsten Carbide Coatings Are An Approved Alternative For Hard Chrome Replacement !!**

**These coatings are hard, dense, well bonded, wear resistant, seal friendly, and protect against corrosion !**

# **HYDRAULIC CYLINDER ROD**

**Shaft Coated With HVOF Applied Tungsten Carbide**

**HVOF Applied Tungsten Carbide Coatings Are An Approved  
Alternative For Hard Chrome Replacement ! !**



**These coatings are hard, dense, well bonded, wear resistant,  
seal friendly, and protect against corrosion !**

# **WEAPONS ELEVATOR CYLINDER ROD – USS WASP**

**Entire Rod Repaired With HVOF Applied Tungsten Carbide As Hard Chrome Replacement**



**Custom Designed TSM "Superfinisher" In Action**



**Superfinished to Customer Specifications of 6 Ra**



**OVERALL ROD DIMENSIONS  
10" Diameter X 24' Long**

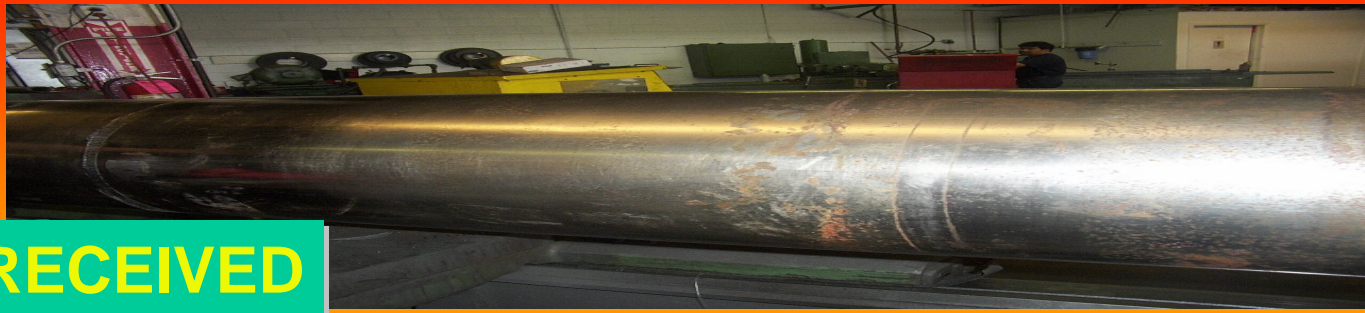
**HVOF Applied Tungsten Carbide Coatings  
Are An Approved Alternative For Hard  
Chrome Replacement !!**



# USS BOONE (FFG-25) – STEERING ENGINE RUDDER HAM REPAIRED WITH TUNGSTEN CARBIDE-COBALT REPLACING THE ORIGINAL HARD CHROME



**AS DELIVERED**



**AS RECEIVED**

# **STERN GATE HYDRAULIC CYLINDER ROD - USS ASHLAND**

**Entire Rod Coated With HVOF Applied Tungsten Carbide As Hard Chrome Replacement**

A photograph of a long, polished hydraulic cylinder rod in a workshop. The rod is positioned horizontally, extending from the left side of the frame towards the right, where it is held by a lathe. The rod has a highly reflective, mirror-like finish. The background shows a workshop environment with a concrete wall and some equipment. The entire image is framed by a thick orange border.

**OVERALL ROD DIMENSIONS  
6" Diameter X 13' Long**

**HVOF Applied Tungsten Carbide Coatings  
Are An Approved Alternative For Hard  
Chrome Replacement !!**

# **NAVY and COAST GUARD**

## **HVOF APPLICATIONS**

***INNOVATION !      EXPERIENCE !      QUALITY !***

# U.S. Navy Landing Craft (LCAC)

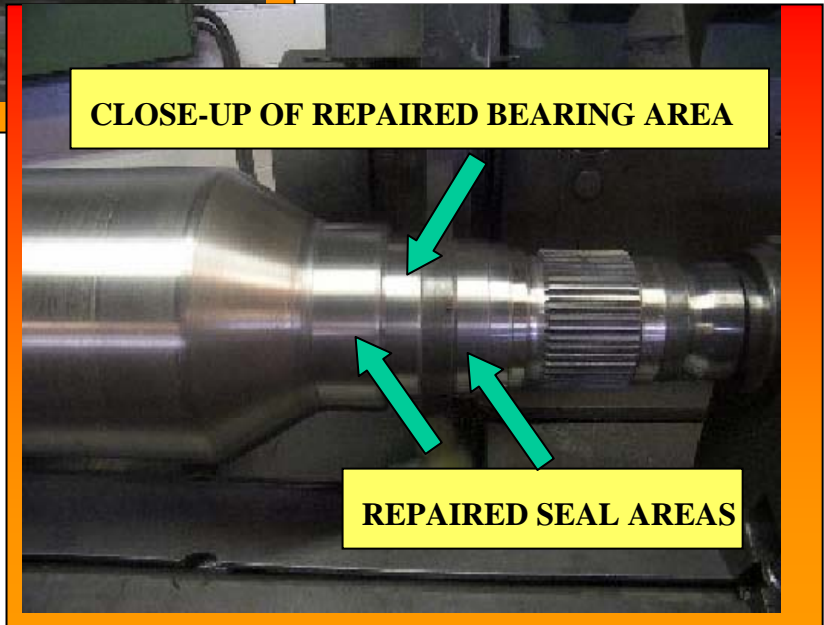


## LIFT FAN SHAFTS

We have coated the bearing journals on more than 600 LCAC lift fan shafts extending the service life from 100 hours (1 Year) to over 700 hours (7 Years) and still counting !!

**PROJECTED SAVINGS: \$20.1M Over 15 Year Service Life !**

CLOSE-UP OF REPAIRED BEARING AREA



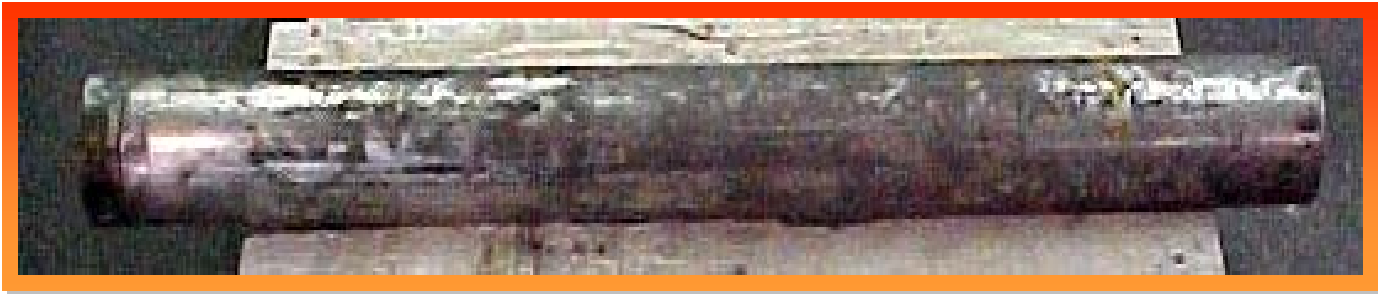
REPAIRED SEAL AREAS



# **HVOF Applied Tungsten Carbide Cobalt/Nickel Coatings (TSM-0010)**

**Thermal Spray Coating (TSM-0010) not only increases corrosion protection but also increases surface hardness resulting in a substantial increase in material life. Normal carbon steel hardness is 22 on the Rockwell C Scale, by coating with Tungsten Carbide the hardness is increased to 64, almost three (3) times the hardness of the original material.**

## **AIRCRAFT CARRIER ELEVATOR STANCHIONS**



**BEFORE**



**AFTER**



# **AIRCRAFT CARRIER FLIGHT DECK ELEVATOR LOCKING PIN**

## **Coated With HVOF Applied Tungsten Carbide For Increased Wear Resistance**

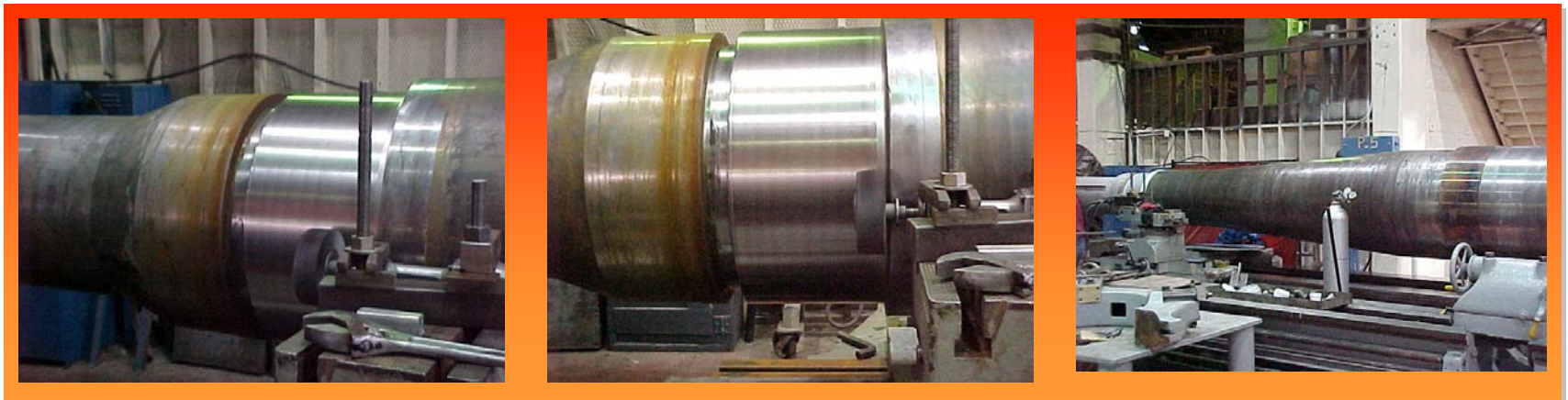


# USS Detroit - 63 Ton Rudder Post

Bearing and Seal Areas Repaired with HVOF Applied Inconel 625



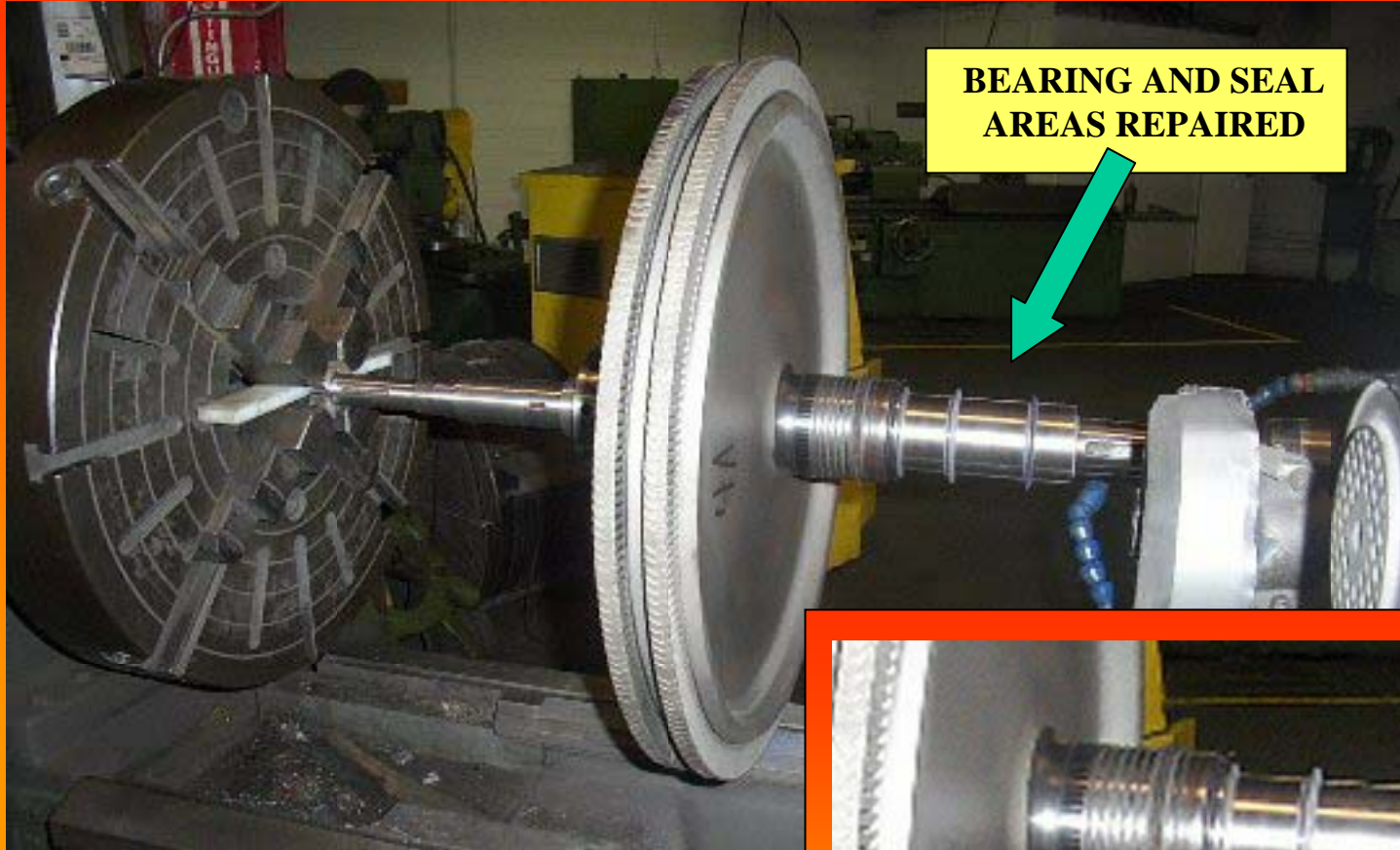
Yes, that was 63 TONS (126,000 lbs.) !!



Saved the customer \$193,000.00 and 25 schedule days

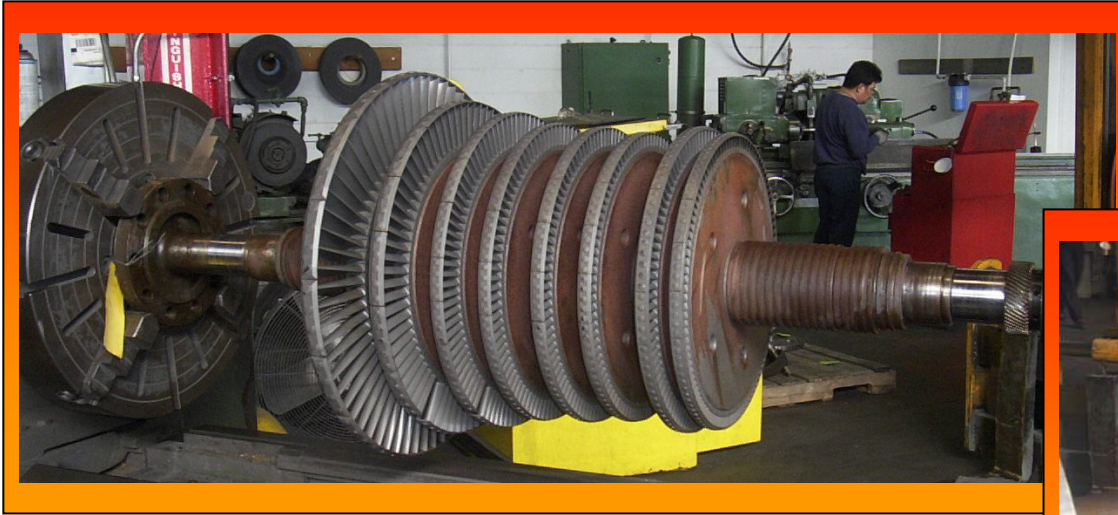
# USS KENNEDY – MAIN FEED PUMP TURBINE

Bearing and Seal Areas Repaired With HVOF Applied Tungsten Carbide

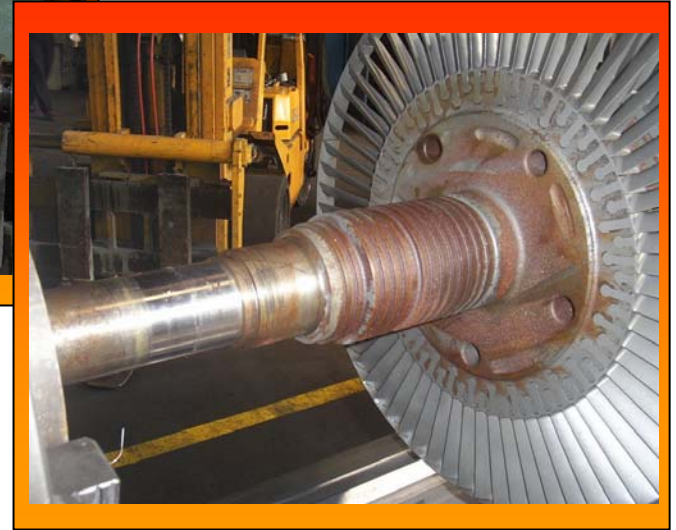




# USS KENNEDY – SHIP'S SERVICE TURBINE GENERATOR



← **BEFORE**



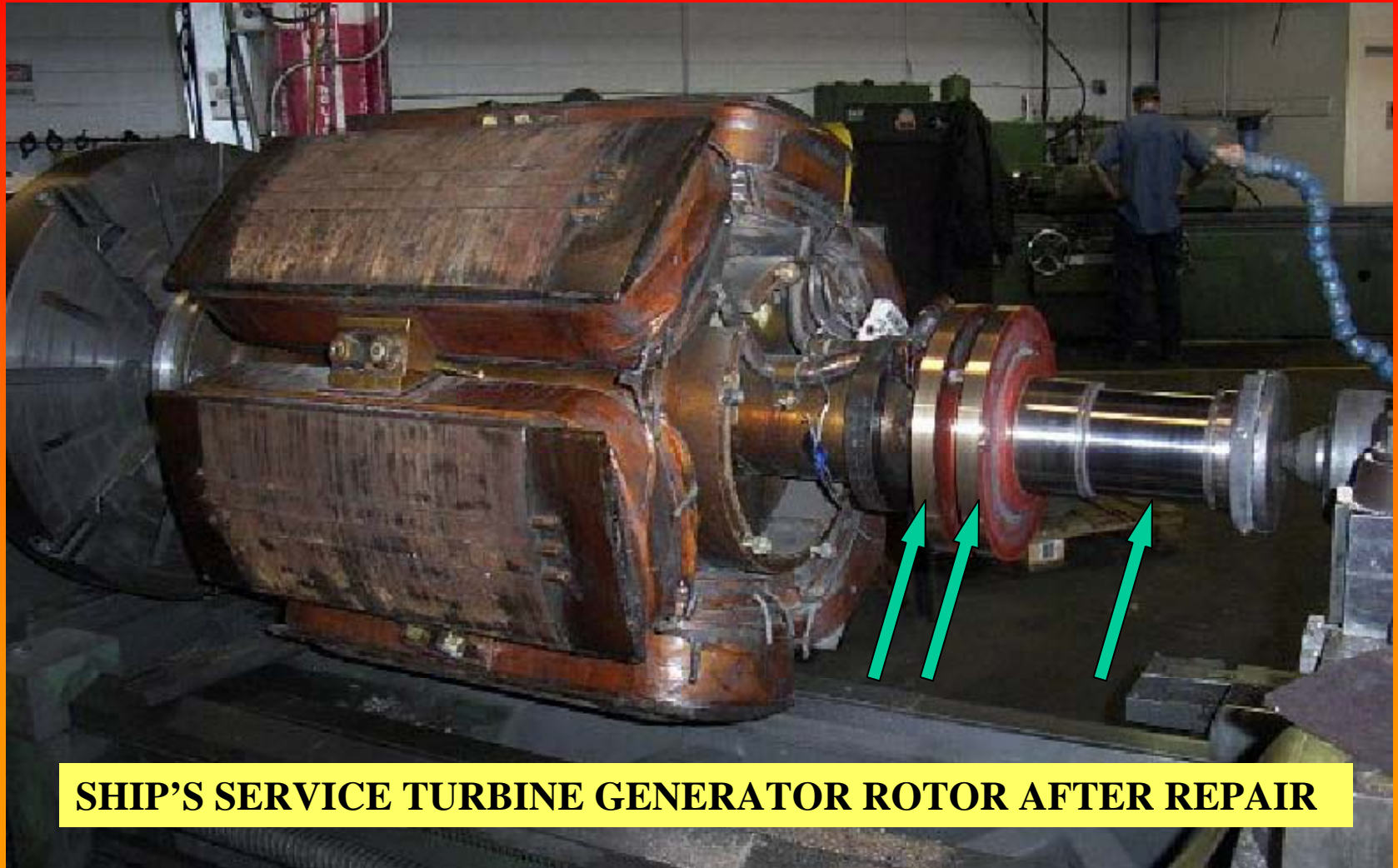
**AFTER** →

Bearing Areas Repaired with HVOF  
Applied Tungsten Carbide



# USS NASHVILLE – SHIP'S SERVICE TURBINE GENERATOR ROTOR

**Bearing Area Repaired With HVOF Applied Tungsten Carbide And Collector Rings Dressed**



**SHIP'S SERVICE TURBINE GENERATOR ROTOR AFTER REPAIR**



# CONTROL ARM LEVER

SHIP'S SERVICE TURBINE GENERATOR – USS NASHVILLE (LPD-14)

**BEARING AREAS REPAIRED WITH  
HVOF APPLIED TUNGSTEN CARBIDE**

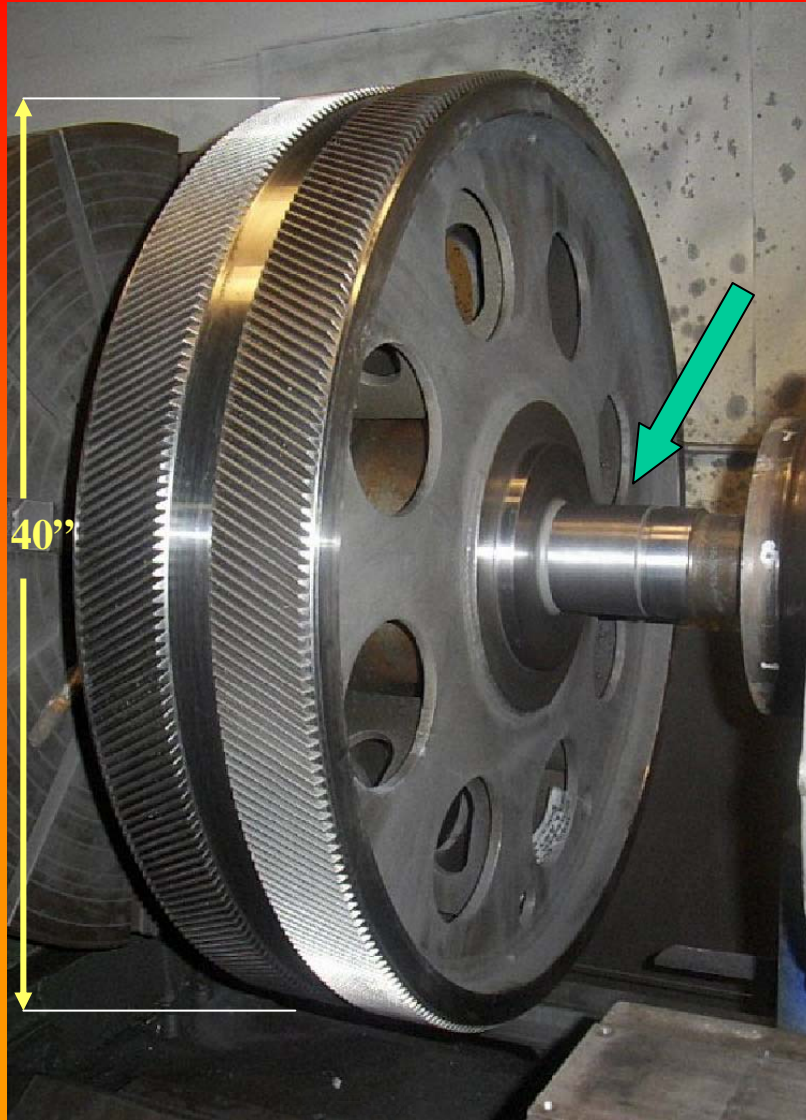


**BEARING AREAS – AFTER REPAIR**

# USS PONCE (LPD-15)

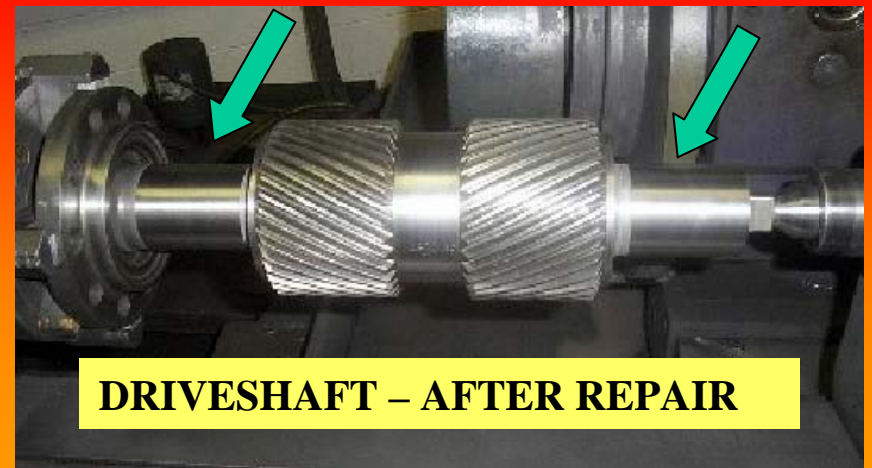
## TURBINE GENERATOR REDUCTION GEAR AND DRIVESHAFT

**Bearing Areas Repaired With HVOF  
Applied Tungsten Carbide**



**REDUCTION GEAR**

**CLOSE-UP OF BEARING  
AREA AFTER REPAIR**



**DRIVESHAFT – AFTER REPAIR**

# SUBMARINE ELECTRIC MOTOR ROTOR

Bearing Areas Repaired With HVOF Applied Tungsten Carbide



**NOTE:** This Is A Special Rotor Designed For Submarine Applications And The Finished Machining Tolerance Was .0002” Over The Entire Length Of The Shaft For Noise Reduction.



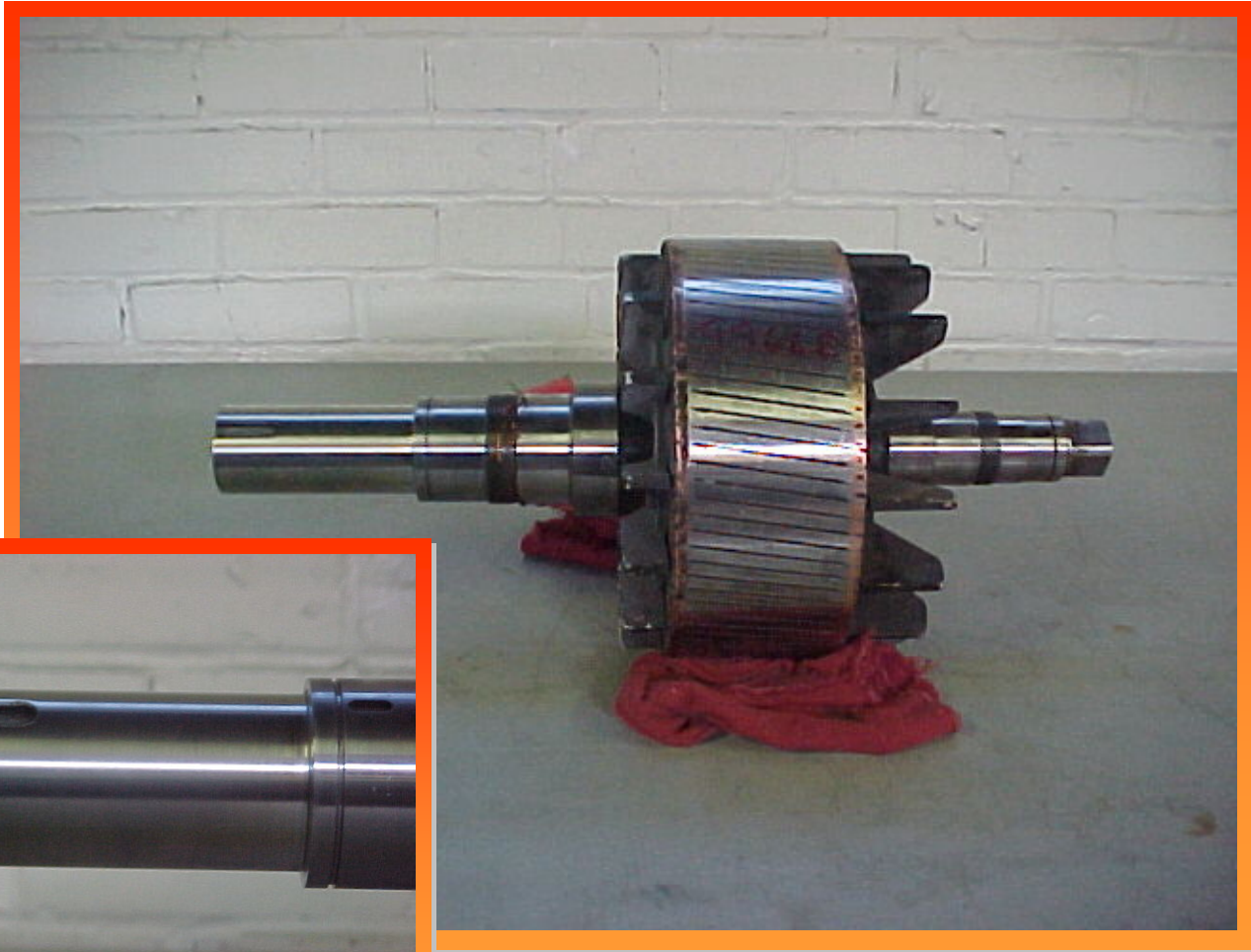
# U.S. COAST GUARD – 110 CLASS RUDDER AND POST

Packing, Bearing, and Seal Areas Repaired With HVOF Applied Tungsten Carbide



# Submarine Vacuum Pump Shaft

## Bearing Area Repaired with HVOF Applied WCCo/Ni



# **USS WASP - STEERING ENGINE RUDDER RAM TUNGSTEN CARBIDE COBALT/NICKEL COATING**



**BEFORE**



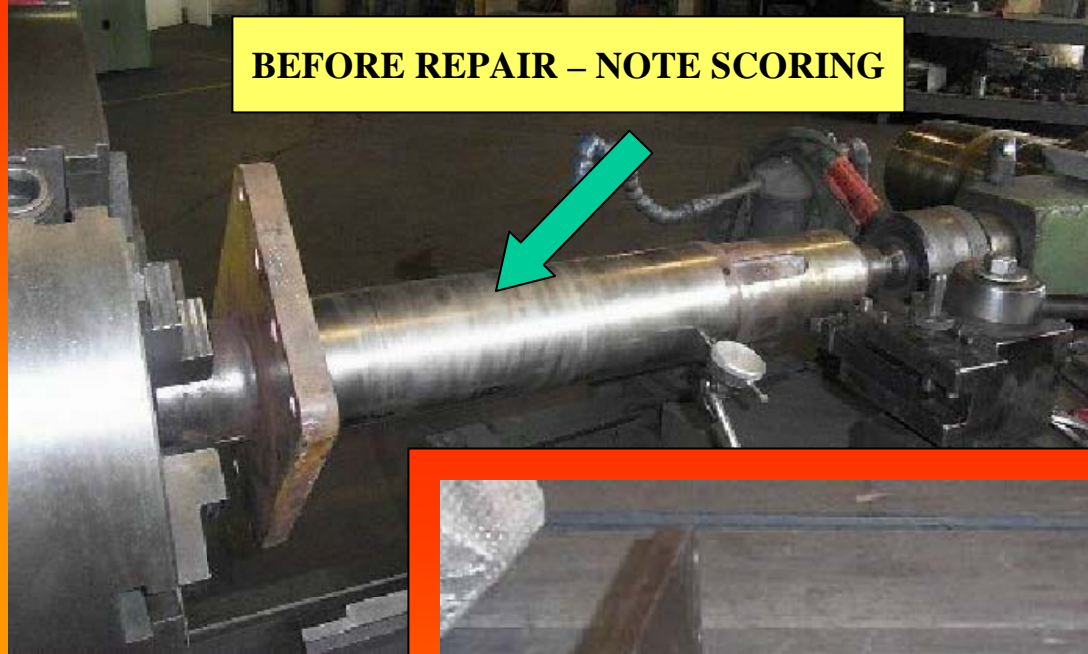
**AFTER**



# FIN STABILIZER SHAFT

Bearing and Seal Area Repaired With HVOF Applied Tungsten Carbide

**BEFORE REPAIR – NOTE SCORING**

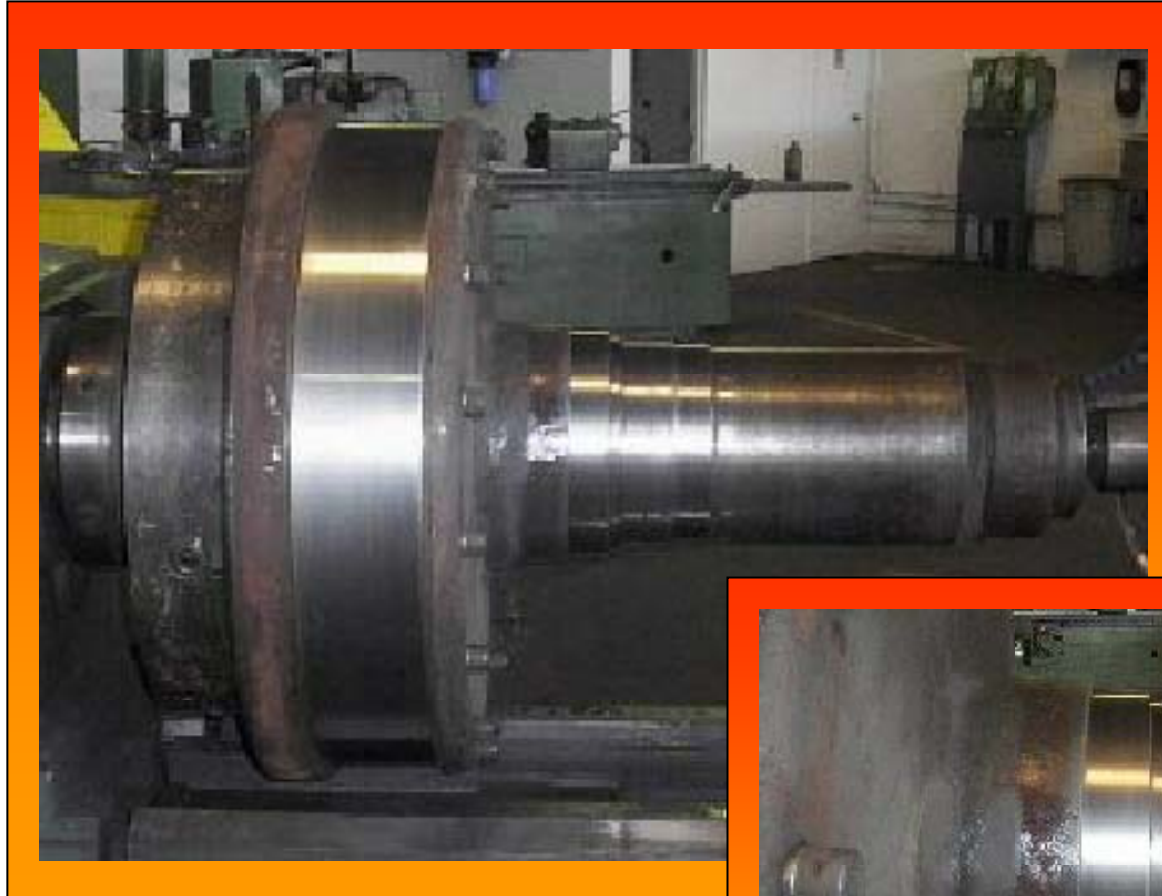


**BEARING AND SEAL AREA AFTER REPAIR**



# COAST GUARD ANCHOR WINDLASS DRUM

Seal Areas Repaired With HVOF Applied Tungsten Carbide



CLOSE-UP OF REPAIRED AREA

# NUCLEAR SUBMARINE SNORKEL INNER PIPE

Entire Snorkel Surface Repaired with HVOF Applied Tungsten Carbide Coating



CLOSE-UP  
OF WORN  
AREA



BEFORE

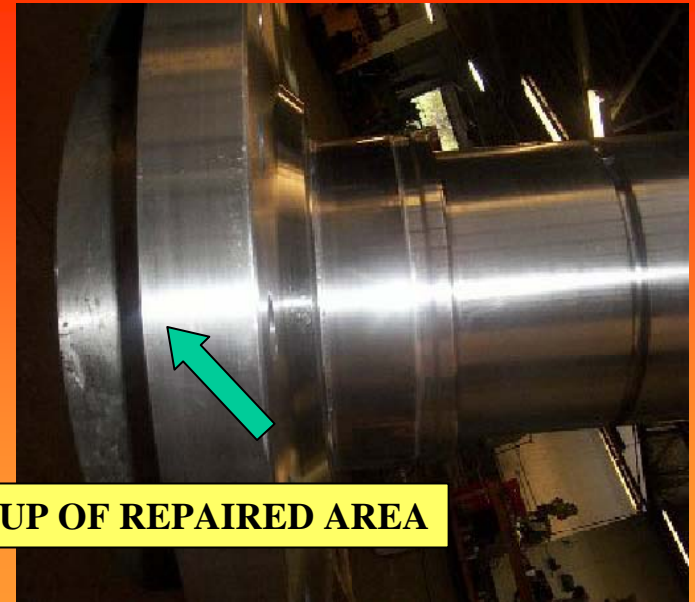


AFTER



# **SUBMARINE SHAFT FOR TOWED ARRAY HANDLING EQUIPMENT**

**Bearing Area Restored With HVOF  
Applied Tungsten Carbide for  
Increased Wear Resistance for  
Naval Undersea Warfare Center,  
Newport Division**



**CLOSE-UP OF REPAIRED AREA**

**Restored bearing  
area completed 400  
hour wear test by  
NUWC, Newport with  
no measurable wear.  
NUWC plans to  
restore all worn  
TAHE with HVOF  
applied tungsten  
carbide**

# **U.S. NAVY - PATROL COASTAL CRAFT**

## **MAIN PROPULSION SHAFTS**

**Bearing Journals Repaired With HVOF Applied Tungsten Carbide**

**U.S. Navy – Patrol Coastal Craft**



**PC-1 Class - Length 170 Feet**



**Main Propulsion Shafts Installed In Strut Bearings After Repair**



# **Z – DRIVE SEAL LINER**

**Military Sealift Command – Cable Laying Ship  
Repaired With HVOF Applied Tungsten Carbide**



**AFTER REPAIR – 26" Diameter Ring**

# GATE VALVE – 12"

Seat Surface Repaired With HVOF Applied Tungsten Carbide

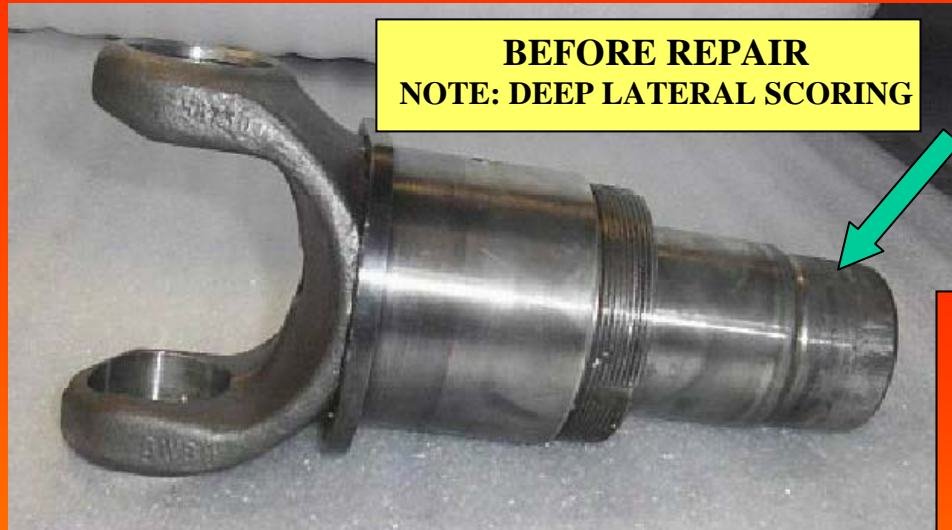


# COMMERCIAL HIGH VELOCITY OXY-FUEL (HVOF) APPLICATIONS

*INNOVATION !      EXPERIENCE !      QUALITY !*

# BOW THRUSTER YOKE

Alignment Fit Repaired With HVOF Applied Tungsten Carbide





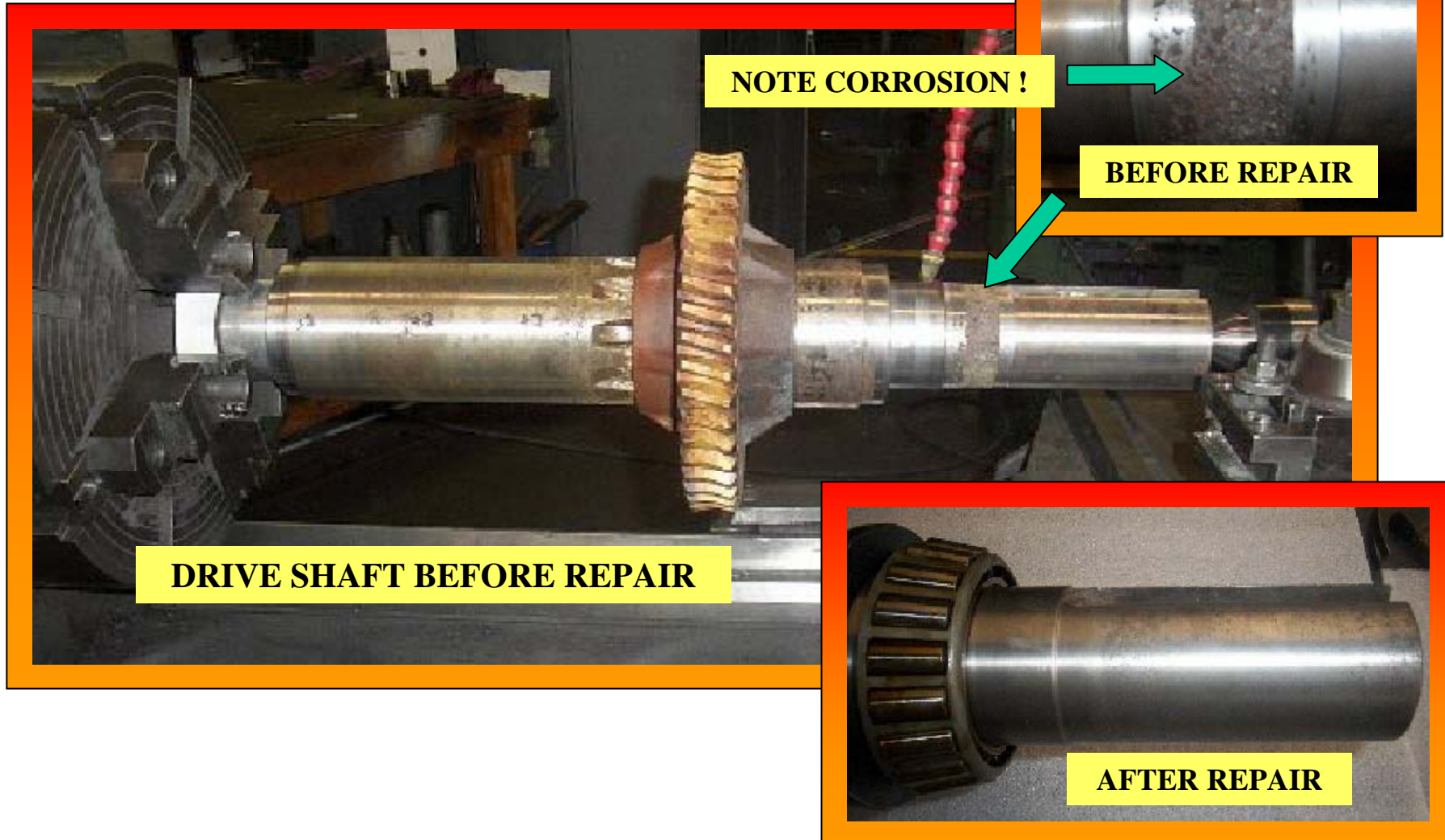
# CSX Lines - Bow Thruster Shaft

**Bearing Journal and Seal Repaired with HVOF Applied WCCo/Ni  
Adjacent Flange Coated for Corrosion Prevention**



# LINE WINCH DRIVE SHAFT

Seal Area Repaired With HVOF  
Applied Tungsten Carbide





# DIESEL ENGINE TURBO BLOWER

Bearing Areas Repaired With HVOF Applied Tungsten Carbide



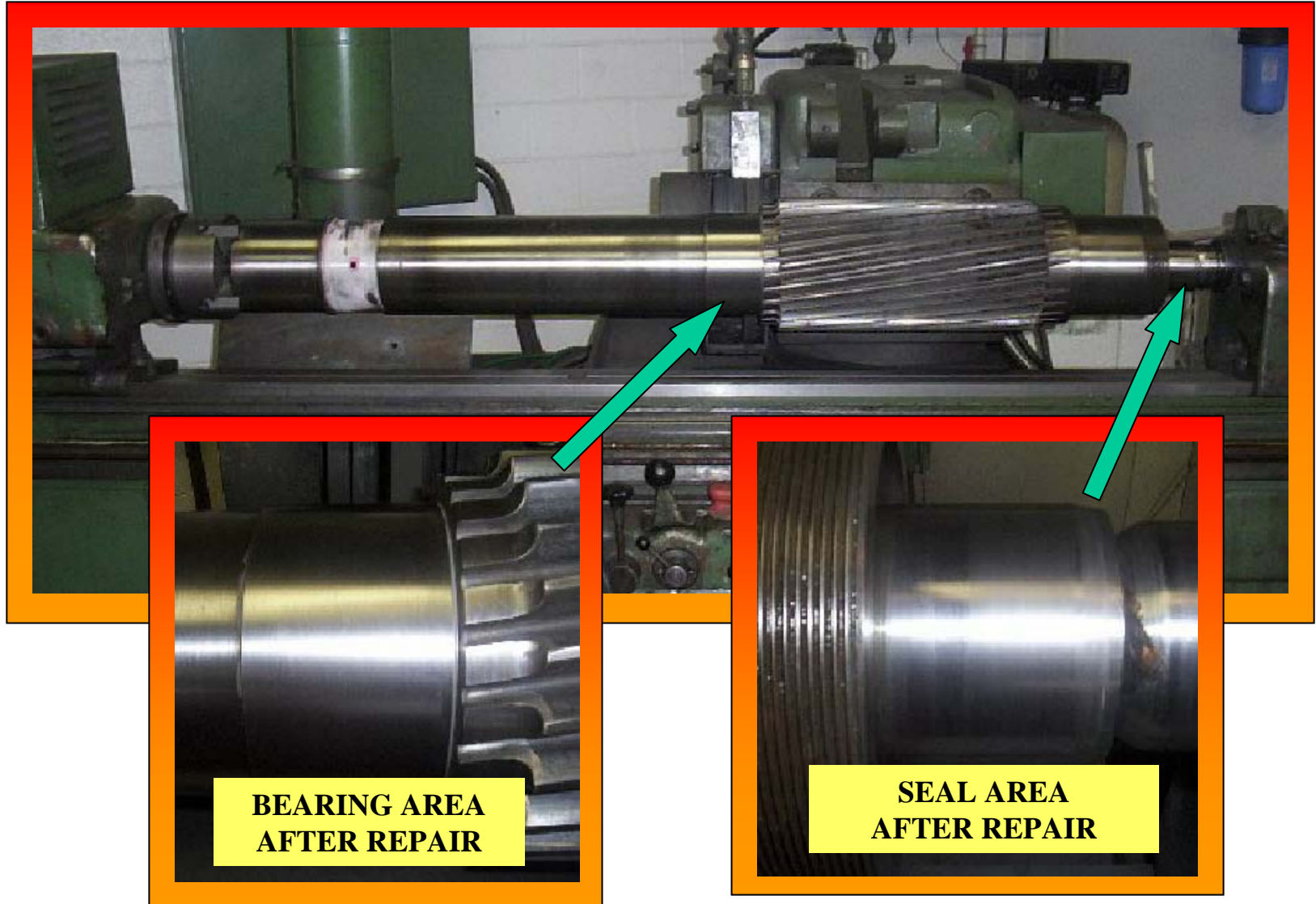
**CLOSE-UP OF BEARING  
AREA AFTER REPAIR**



**CLOSE-UP OF BEARING  
AREA AFTER REPAIR**

# PINION GEAR – TUGBOAT GEARBOX DRIVE

Bearing And Seal Area Repaired With HVOF Applied Tungsten Carbide





# Z-DRIVE SEAL LINERS

**Both Seal Liners Put Into Operation at the Same Time.  
After One Year of Operation.....**

**The Un-Coated Liner Has (2) 1/8" Grooves Worn by the Seal !**

**The Coated Liner Showed NO Signs of Wear !!**  
(only a slight discoloring of the coating in the seal area)



# TUGBOAT Z-DRIVE SEAL LINER

Seal Area Coated With HVOF Applied Tungsten Carbide



# **STEERING DRIVE SEAL RINGS**

**Wear Areas Coated With HVOF Applied Tungsten Carbide**



**Increased Wear Resistance Provides Longer Service Life !**

# **OIL DISTRIBUTION BOX SHAFT FOR CHANGEABLE PITCH PROPELLER**

**Bearing And Seal Areas Repaired With HVOF Applied Tungsten Carbide**



**BEFORE**



**AFTER**



# BUTTERFLY VALVE STEM

New Shaft Coated With HVOF Applied Tungsten Carbide To Prevent Wear



NEW VALVE STEM WITH COATING



OLD VALVE STEM

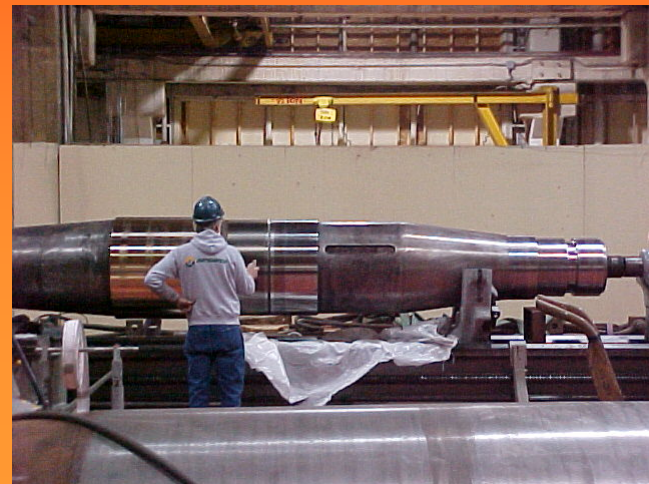
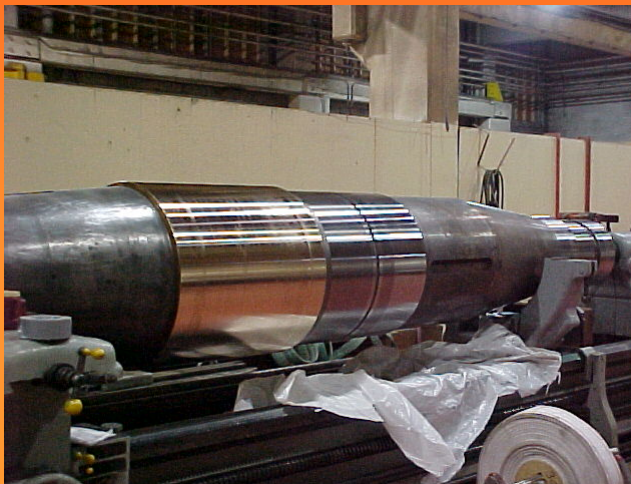
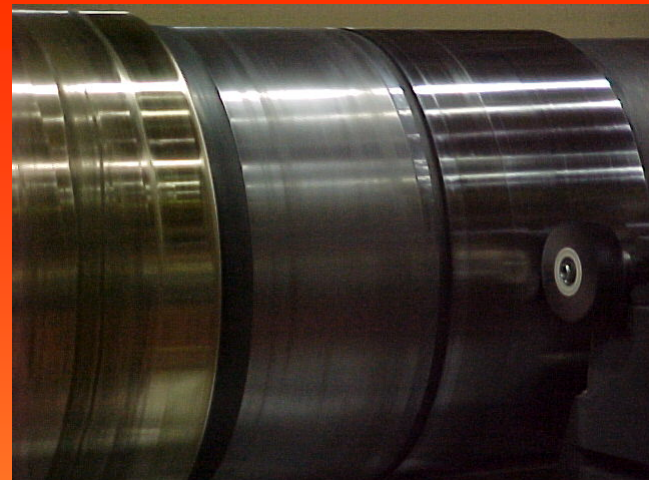
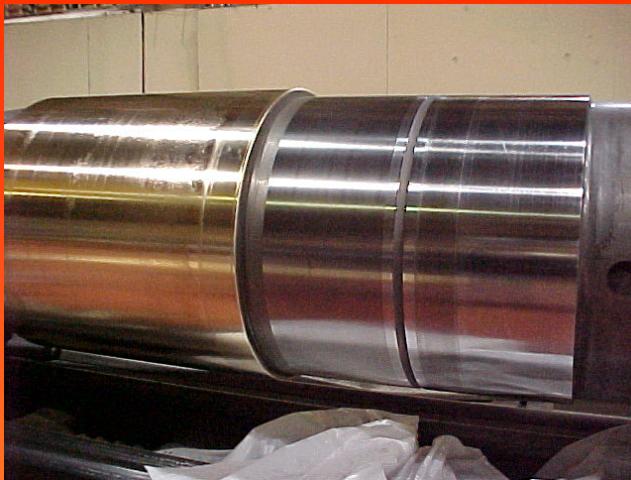
# **NAVY and COAST GUARD ELECTRIC ARC APPLICATIONS**

***INNOVATION !    EXPERIENCE !    QUALITY !***

# USS Halyburton – Rudder Post

Seal Area Repaired with Arc Wire Al/Br

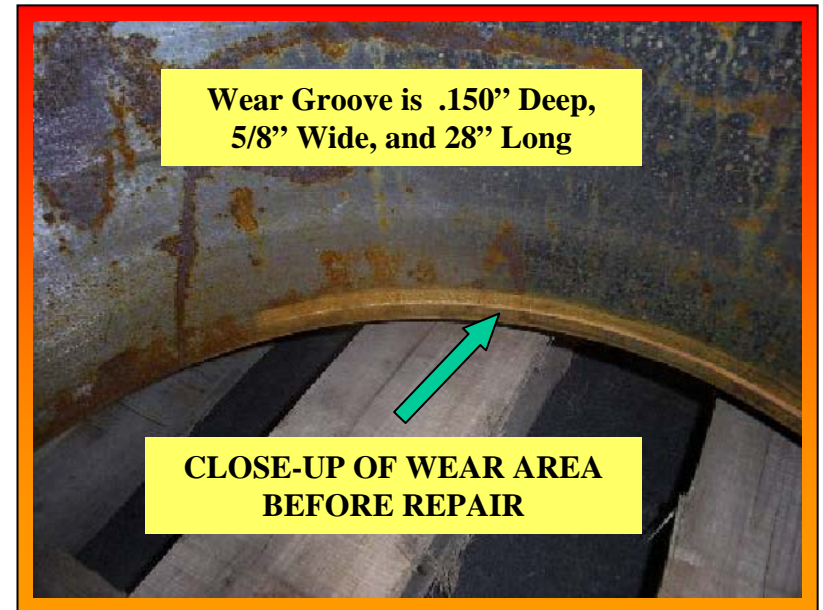
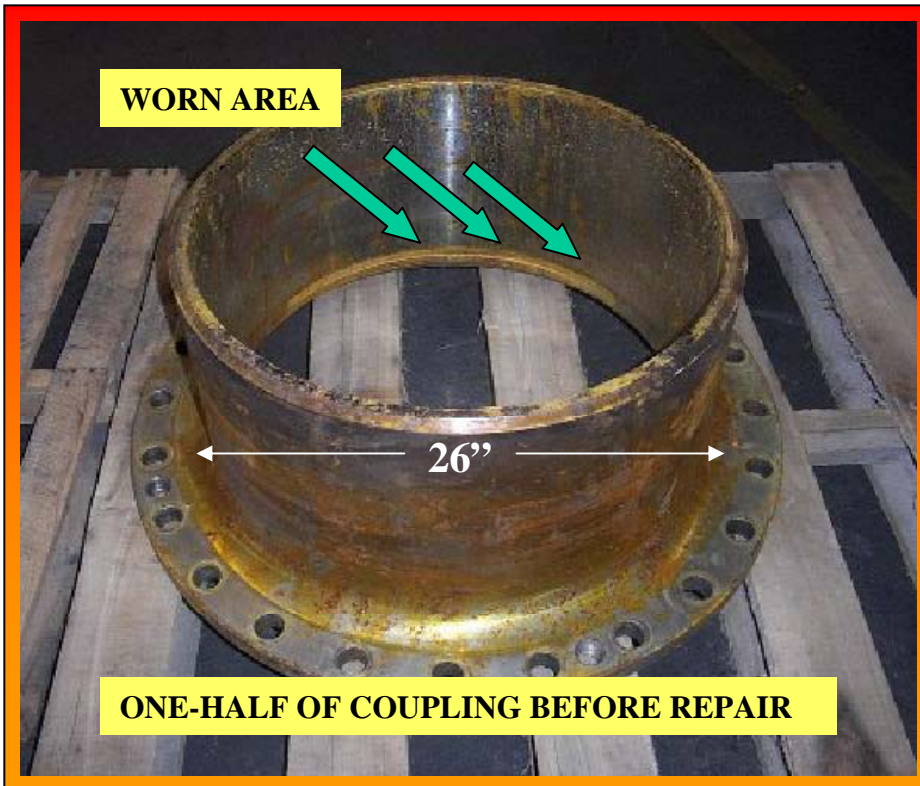
Bearing Area Repaired with Arc Wire SS





# DIESEL ENGINE COUPLING – MILITARY SEALIFT COMMAND

## Wear Groove Repaired With Arc-Wire Applied Inconel 625





# **AIRCRAFT CARRIER HANGAR BAY DOOR ROLLERS**

**Roller Surface Area Coated With Arc-Wire Applied**

**Pseudo-alloy AlBr-Mo**



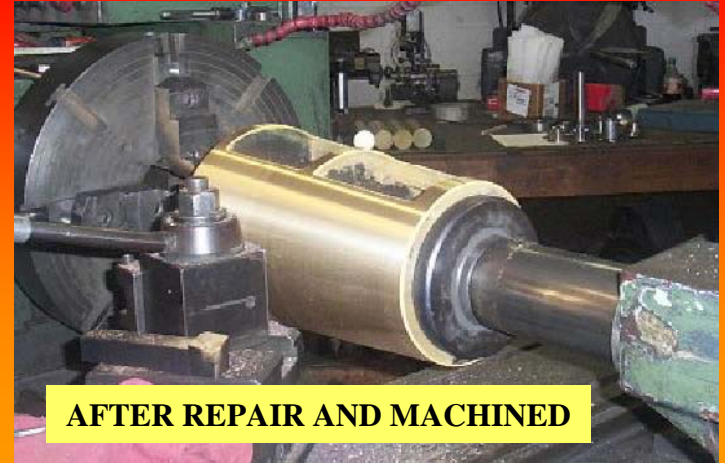
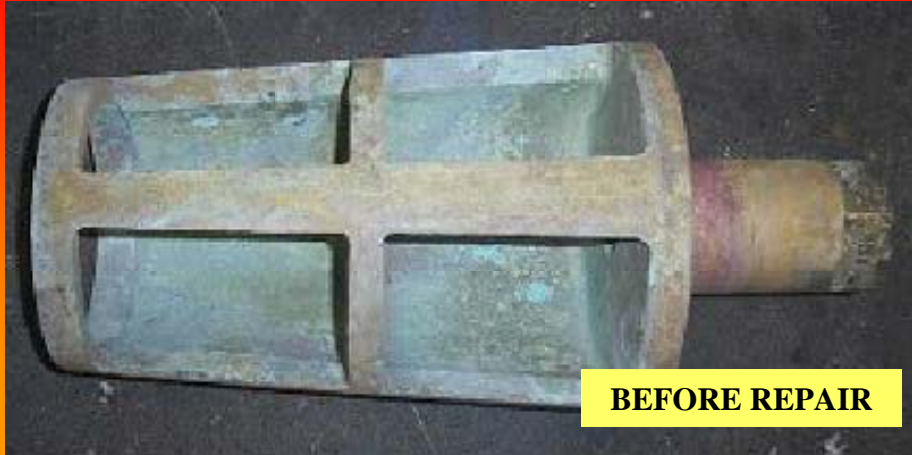
# Submarine Bow Plane Housing Mating Flanges Repaired with Arc Wire Molybdenum





# PLUG FOR DUPLEX STRAINER

Repaired Plug With Arc-Wire Applied AlBr And Machined to Fit



# **U.S. Coast Guard - CHANGEABLE PITCH PROPELLER HUB**

**Damaged O-Ring Seal Areas Repaired With Arc-Wire Applied Bronze**



**U.S. COAST GUARD – 210 CLASS  
CHANGEABLE PITCH PROPELLER HUB**



**PORT – AFTER REPAIR**

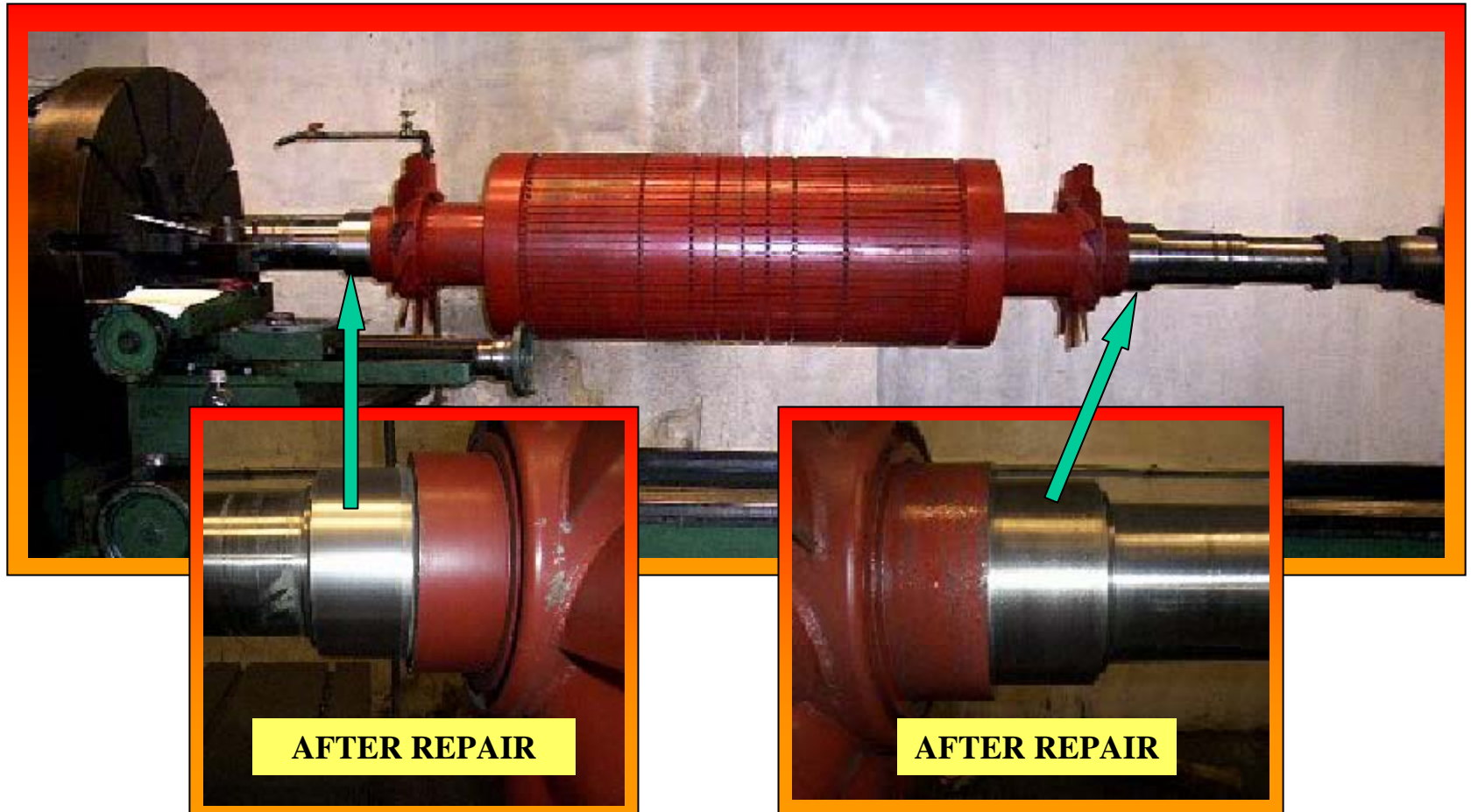


**AFTER REPAIR – CLOSE-UP  
OF O-RING SEAL AREA**



# ELECTRIC MOTOR GENERATOR ROTOR

**Thrust Bearing Areas Repaired With Arc-Wire Applied Inconel 625**





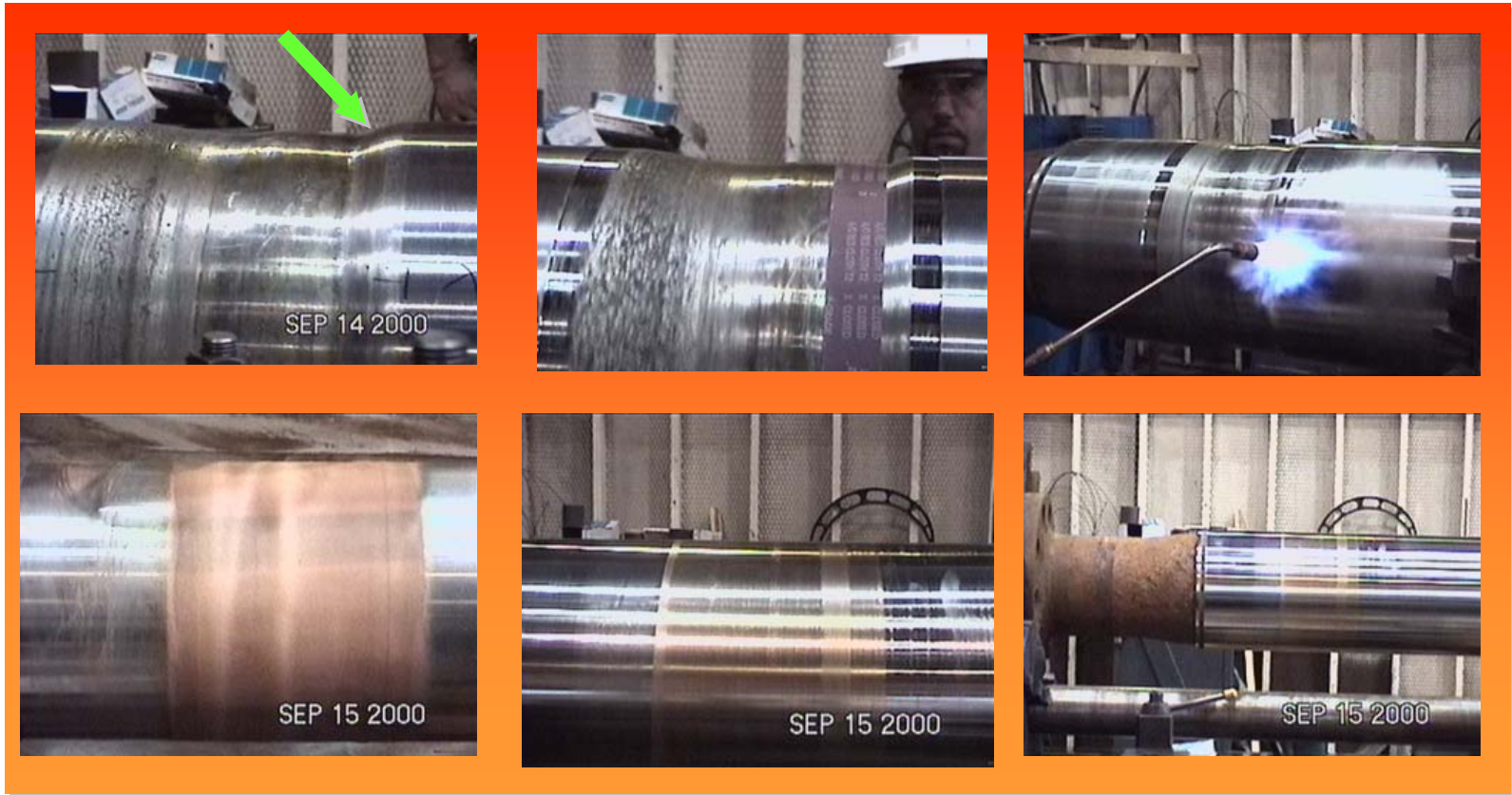
Thermal Spray & Machine Inc.

# COMMERCIAL ELECTRIC ARC SPRAYED APPLICATIONS

*INNOVATION !      EXPERIENCE !      QUALITY !*

# **MV OCEAN BREEZE - Main Propulsion Shaft Repaired with Arc Wire Al/Br and Finished with WCCo/Ni**

**Shaft Worn 1 1/4" on Diameter ! – Repaired in Less Than 24 Hours!**



**TSM saved this Customer over \$200,000 and more than 2 weeks downtime ! !**

# MAIN ENGINE COUPLING HUB - TUGBOAT



**I.D. Of Hub  
Repaired With  
Arc-Wire Applied  
Carbon Steel**



**AFTER REPAIR**



# **LOW PRESSURE CHAMBER FOR OIL DISTRIBUTION SYSTEM FOR CHANGEABLE PITCH PROPELLER**

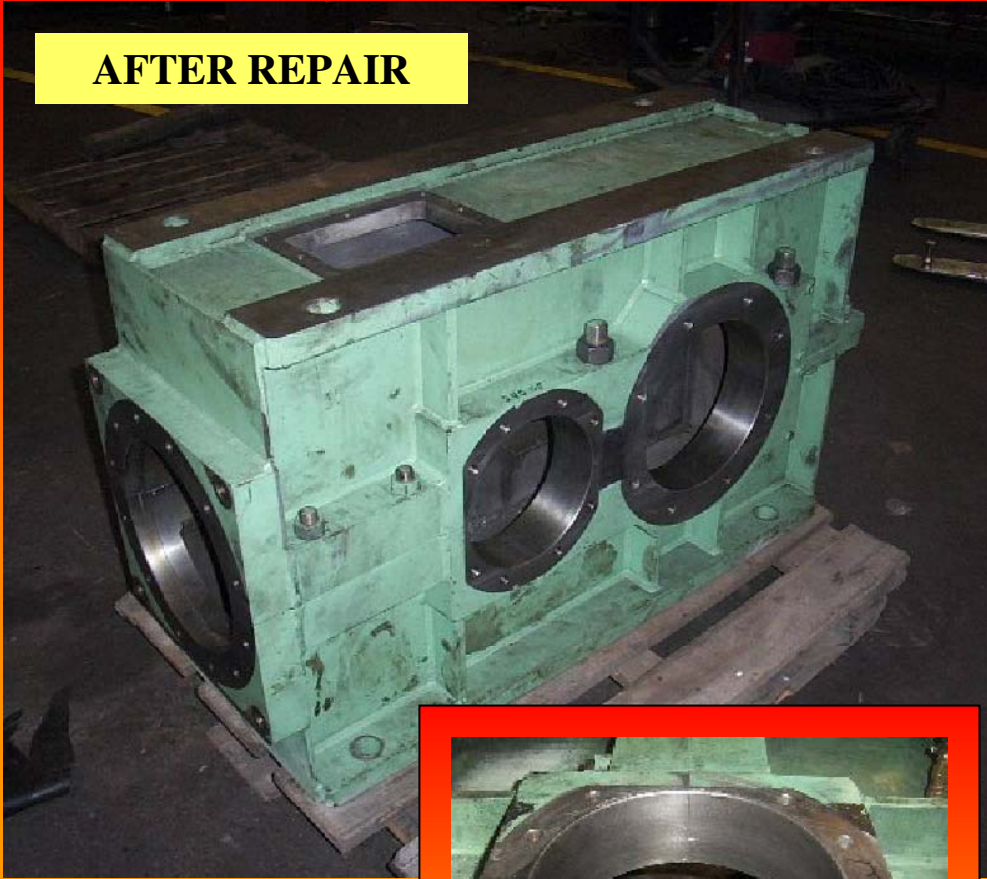
**I.D. Areas (Corrosion) Repaired With Arc Wire Applied High Carbon Steel**



# GEARBOX CASING

Bearing Area Repaired With Arc-Wire Applied Inconel 625 And Line Bored

**AFTER REPAIR**



**CLOSE-UP AFTER  
BEING REPAIRED  
AND LINE BORED**



**AS-SPRAYED  
BEFORE LINE  
BORING**





# ELECTRIC MOTOR SHAFT



**Impeller Fit Area Repaired With  
Arc-Wire Applied CrSS**





**PLASMA APPLIED  
NON-CONDUCTIVE COATING**

***INNOVATION !      EXPERIENCE !      QUALITY !***

# SUBMARINE CABLE CONNECTORS

**Connector Bodies Coated With Plasma Applied NCC Ceramic Coating To Prevent Corrosion Caused By Surface Electrical Currents On The Connectors. This Corrosion Would Cause The Polyurethane Coating To Separate Resulting In Failure.**



**TSM HAS  
COATED MORE  
THAN 25,000  
CONNECTORS !**

## **SUCCESS STORY**

**SINCE TSM HAS STARTED  
APPLYING NCC COATING TO  
SUBMARINE CABLE  
CONNECTORS, THERE HAS  
NOT BEEN ONE DOCUMENTED  
FAILURE !**



**COMPLETED CONNECTOR WITH  
POLYURETHANE COATING**

# **SSN SPECIAL PURPOSE MOTOR LEAD CONNECTOR**

**Connector Body Coated With Plasma Applied Non-Conductive Ceramic Coating To Prevent Corrosion By Galvanic Action**



**UNCOATED**

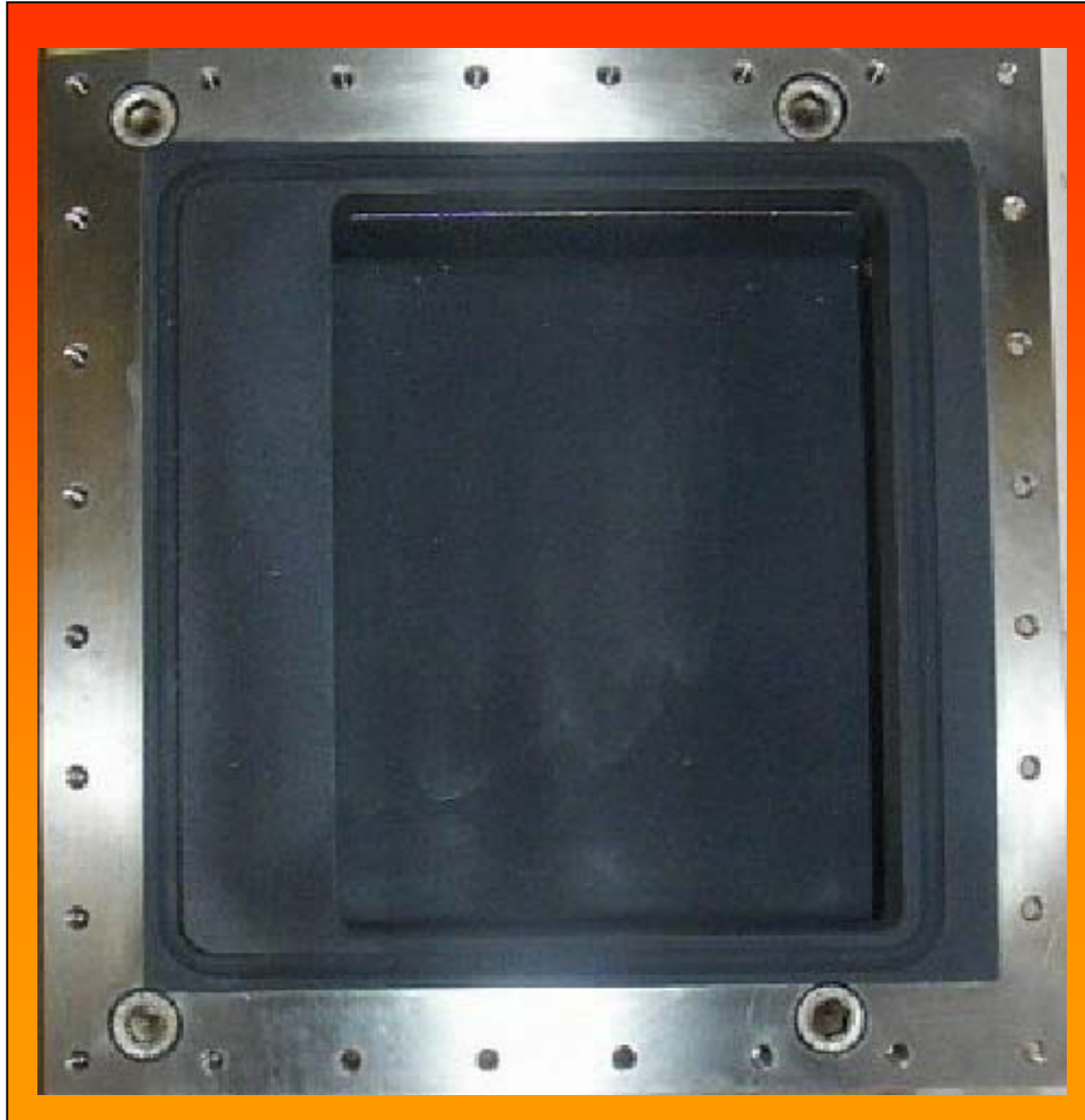


**COATED**



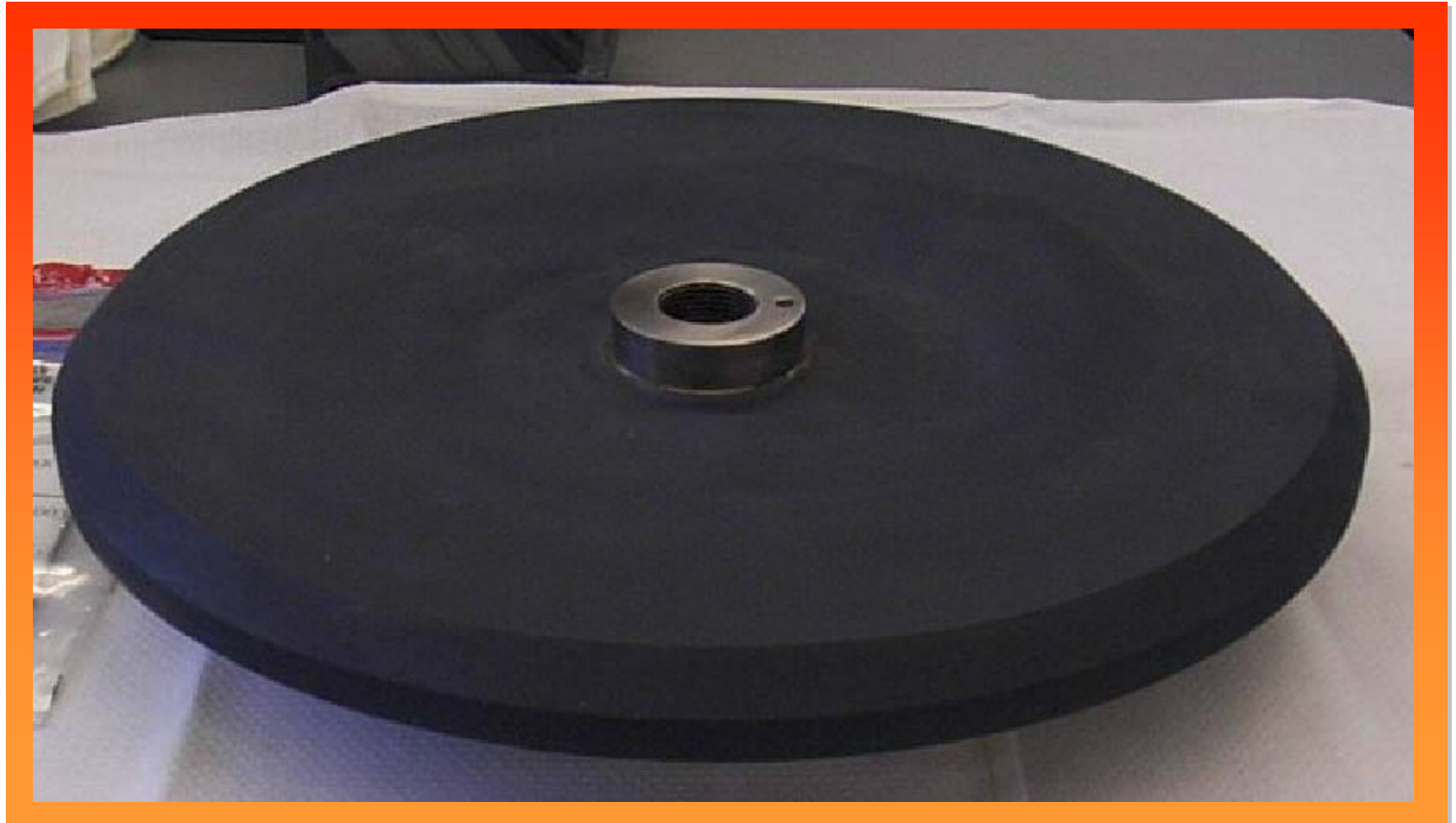
# SUBMARINE ELECTRONICS ENCLOSURE

Interior Of Enclosure NCC Coated



# **SUBMARINE AIR INTAKE FLAPPER VALVE**

**Valve Flapper Coated With Plasma Applied Non-Conductive Ceramic Coating To Prevent Corrosion By Galvanic Action**



# **SUBMARINE AIR INTAKE VALVE FLAPPER ARM**

**Valve Arm Coated With Plasma Applied Non-Conductive Ceramic Coating To Prevent Corrosion By Galvanic Action**



**AFTER COATING**



**VALVE ARM  
"AS RECEIVED"**



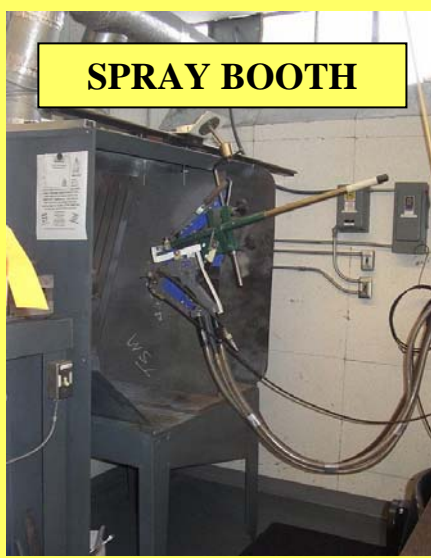
# SUBMARINE SONAR TRANSDUCER PLATE

Surface Coated With Plasma Applied Non-Conductive Ceramic Coating (NCC) To Resist Corrosion From Galvanic Action



# NON-CONDUCTIVE COATING DIVISION

**SPRAY BOOTH**



NON-CONDUCTIVE COATING  
DIVISION



**CLEANING & SEALING**



**RECEIVING & PREP**



Thermal Spray & Machine Inc.

**NCC DIVISION**

**A Segregated,  
Independent  
Production Cell**

**Q.A. & SHIPPING**



# **U.S. ARMY HELLFIRE MISSILE EXHAUST DIFFUSER**

**Protected By Plasma Applied Thermal Barrier Coating Of  
Yttria Stabilized Zirconium Oxide To Deflect Intense Heat  
Of Missile Exhaust Away From Helicopter**



**Diffusers Used On U.S. Army  
Blackhawk Helicopters**

**Success Story ! 629  
Diffusers Coated By  
TSM For U.S. Army !**